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Optimal transmission regulation of an integrated energy market

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ABSTRACT

The capacity of the transmission network determines the extent of integration of a multi-national energy market. Cross-border externalities render coordination of network capacity valuable. Is it then optimal to collect regulatory powers in the hands of a single regulator? Should a common system operator manage the entire network? I show that optimal network governance depends on (*i*) whether the centralized regulatory agency is able to balance the interests of the different countries; (*ii*) asymmetries across countries in the gains from market integration; (*iii*) network characteristics (substitutability versus complementarity); and (*iv*) the social cost of operator rent.

1. Introduction

The European Commission (2007) views the completion of an integrated European energy market as essential for ensuring competitiveness, sustainability and security of energy supply in Europe. Market integration depends crucially on the transmission network connecting the member states being capable of reliably transporting energy from power plants in one country to consumers in another. Increasing shares of solar and wind energy place additional requirements on the grid as production and energy flows become more volatile. The transmission network is considered a natural monopoly in many countries. In a monopoly setting, establishing an efficient transmission network boils down to implementing a well designed regulatory policy.

Most liberalized electricity markets have been restructured one country at a time. Owing to the national scope of liberalization, transmission regulation has also been national in scope. National regulatory agencies govern national system operators who own and manage the national transmission networks. The question is whether transmission governance along national borders is still optimal in a multi-national energy market. In an integrated energy market, improvements in grid capacity at home have implications even abroad because the removal of each transmission bottleneck affects energy flows and prices across the entire market. With too narrow a focus on domestic effects, national regulatory agencies run the risk of ignoring externalities abroad when devising regulatory policy for the national system operator.

Two examples from the Nordic electricity market illustrate the influence of narrow national interests over transmission management. The Nordic electricity market constituted the world's first multi-national liberalized electricity market and now spans Denmark, Finland, Norway and Sweden.[1] In the spring of 2008, a number of transmission lines connecting southern Norway and southern Sweden broke down, severely limiting export capacity to Sweden. According to the Norwegian regulator, the line failures were largely due to insufficient maintenance by the Norwegian system operator, Statnett. Admitting that the repairs were taking an unusually long time, Statnett emphasized that the security of supply for Norwegian consumers was never jeopardized. Meanwhile, the consumers in southern Norway had been enjoying comparatively low electricity prices. The effects on consumers and producers in Sweden (or elsewhere) seem to have been absent from the Norwegian discussion.

In 2010, the European competition authority warned the Swedish system operator Svenska Kraftnät that the practice of alleviating domestic congestion problems by limiting exports to Denmark could be illegal. By cutting the outflow of electricity, Svenska Kraftnät was able to offset excess demand in southern Sweden, thereby achieving its objective of a uniform electricity price across Sweden. Danish

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[1] In addition, the Nordic market has interconnections with Estonia, Germany, Poland, Russia and The Netherlands.

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interests, concerned with higher electricity prices in Denmark, filed a complaint with the EU accusing Svenska Kraftnät of abusing its monopoly position as the sole provider of Swedish transmission capacity. Svenska Kraftnät has subsequently decided to solve Swedish congestion problems through means other than reducing export capacity.[2]

With the cross-border externalities in mind, would it not be better to establish a common regulatory agency responsible for the entire transmission network? And should the national system operators be merged into a common system operator? In this paper I formally analyze these *horizontal* aspects of network governance. The discussion has, so far, centered around the costs and benefits of *vertical* separation of transmission operation from production; see e.g. Cremer et al. (2006) for an analysis and Pollitt (2008) for an account of the arguments. For the fear of integrated utilities discriminating against competitors and investing inadequately in their networks, the EU recommends full ownership unbundling of transmission and production assets (EU, 2009b). However important vertical structure may be, overall network performance depends crucially on the incentives induced by the regulatory policies adopted by the different member states. The newly established Agency for the Cooperation of Energy Regulators (ACER) reflects this concern. ACER is furnished with the task of coordinating transmission regulation across the EU member states and deciding on the terms and conditions for access to cross-border infrastructure in case of national disagreement. On the system level, The European Network of Transmission System Operators for Electricity (ENTSO-E) is a collaboration of the system operators in the EU with the objective of coordinating and promoting system operator interests.

I consider a two-country energy market with interconnected networks. Network reliability is a measure of market integration and increases with maintenance spending in both networks. Gains from energy trade render network reliability valuable, but maintenance and transfer payments are costly. The purpose of regulation is to provide the system operators with the appropriate incentives for network maintenance while minimizing maintenance cost and transfer payments. First-best optimal spending occurs at the point at which the marginal benefit of network reliability equals the marginal social maintenance cost.[3]

Network governance is a question of both how many regulators there should be and the optimal number of system operators (transmission owners). Therefore, a taxonomy of network structures needs to be compared with one another. The Nordic electricity market exemplifies the governance structure labeled *Separation* in Table 1. Separation constitutes the most decentralized network structure: Every country has its own national system operator (NSO) regulated by a national regulatory agency (NRA). An advocated contender is full centralization, here labeled *Integration*, where the responsibility for managing the entire transmission grid is merged in a common system operator (CSO), supervised by a common regulatory agency (CRA). *Common regulation* constitutes a compromise between Separation and Integration and features a set of NSOs jointly regulated by a CRA. An example of Common regulation is Great Britain, where Ofgem regulates the three transmission owners National Grid Electricity Transmission, Scottish Power Transmission Limited and Scottish Hydro-Electric Transmission Limited. To complete the picture, *Common agency* describes a situation where multiple national regulatory agencies independently regulate a single CSO. In practice, proponents of a single system operator typically envision a complementary coordination of regulatory policies. For example, an investigation of the desirability of a single Nordic system operator concluded that national governments should simultaneously be forced to relinquish some (regulatory) autonomy, otherwise interference from the national governments would create inefficiencies in system operation (EMG, 2008). I therefore skip a detailed analysis of Common agency at this stage, although one might want to consider it for the sake of completeness.

Table 1
A taxonomy of network governance structures.

	National regulatory agencies	Common regulatory agency
National system operators	*Separation*	*Common regulation*
Common system operator	*Common agency*	*Integration*

To compare welfare under the different structures, I assume that the common regulator selects the (for him) optimal regulatory policy. Under Separation, on the other hand, the two national regulatory agencies (NRAs) play a non-cooperative game against each other: Each NRA chooses its regulatory policy to maximize national welfare given the choice of policy by the other NRA.

A benevolent common regulator who can commit to complete long-term contracts can always replicate any set of contracts implemented by the national regulatory agencies and can potentially do better. Centralized regulation is always optimal in this case. Therefore, decentralized regulation can be optimal only if (*i*) the regulator is non-benevolent; or (*ii*) the regulator has commitment problems; or (*iii*) there are problems of contractual incompleteness at the centralized level. This paper analyses regulation from a political economy standpoint.[4] The countries differ in their valuation of market integration because of cross-country differences in the gains from trade. The common regulator maximizes a weighted average of national welfare in the two countries, where the weights are meant to capture the political influence of the respective countries over the design of the common regulatory policy.

The trade-off between centralized and decentralized regulation is between internalizing cross-border externalities of market integration and tailoring regulatory policies to each individual country to reflect differences in the valuation of market integration. National regulatory agencies (NRAs) provide insufficient incentives for network maintenance because they only consider the domestic and not the foreign gains from market integration. In addition, total maintenance spending is suboptimally distributed across the network because of a lack of coordination between the NRAs. Establishing a common regulatory agency (CRA) takes care of the coordination problem. However, total maintenance spending can be too high or too low under centralized regulation depending on the weight of the different countries in the objective function of the common regulator. If, for example, a country with very little to gain from market integration controls the CRA, maintenance incentives are vastly insufficient because the CRA grossly understates the value of market integration. In this case, regulatory decentralization is preferable to centralization. The key to establishing a well-functioning common regulatory agency thus lies in ensuring a balanced political influence across countries. With sufficiently equal distribution of political power, no country can exert enough influence over the regulatory policy to tilt it in one's own favor.

[2] The measures include dividing Sweden into multiple price areas and transmission investments to remove domestic bottlenecks.

[3] Obviously, the regions do not necessarily have to be countries. The model could equally well be applied to study market integration between regional electricity markets in the US or elsewhere. Also, it is not necessary that electricity is traded on a common power exchange. In fact, the electricity markets do not even have to be liberalized. The crucial assumptions in the model are that capacity expansions are costly, capacity changes have effects on welfare in both regions, and there could be strategic interaction between regions in the decision to expand capacity. It follows that the qualitative insights gained in this paper regarding network reliability versus maintenance cost carry over to the long-run problem of network capacity versus investment cost.

[4] Olsen and Torsvik (1993) analyze the case of non-commitment. They show that decentralized regulation can mitigate dynamic inefficiencies stemming from post-contractual exploitation by the centralized regulator. The system operator performs a multitude of tasks, such as short-term balancing of energy supply (Rious et al., 2008), some of which are not fully contractible. Incomplete contracting and optimal delegation in integrated energy markets are interesting topics for future research.